DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SPACE COMMAND

MAY 16 2019

MEMORANDUM FOR DISTRIBUTION

FROM: AFSPC/CC
150 Vandenberg Street, Suite 1105
Peterson AFB CO 80914-4020

SUBJECT: Air Force Space Command (AFSPC) Long-Term Science and Technology (S&T) Challenges

1. Today's complex security environment is defined by rapid technological change, global access to new capabilities, and the reemergence of strategic competition by our adversaries in every domain, including space. AFSPC must guide S&T activities that enable development and delivery of capabilities to ensure our freedom of action within this evolving domain.

2. This memo is aligned to AFSPC enterprise strategy and architecture and addresses mandates captured in the National Defense Strategy, the National Strategy for Space, the Air Force Science and Technology Strategy, and the AFSPC Commander's Strategic Intent. The common message across all of these drivers is clear – to dominate in time, space, and complexity in future conflicts, the United States must innovate and bring new S&T to bear in space that will enable joint capabilities to succeed in a multi-domain conflict.

3. The space domain of the future will be characterized by an increasing private, industrial, and government presence. This presence includes sustained commercialization of near-Earth space, the exploitation of space resources, an increased human presence in space, and the push to establish a long-term investment on the moon and beyond. The multinational confluence of these political, social, technological, economic, and environmental trends will redefine this global security context.

4. With this will come the need to: protect and defend U.S. national interests in and beyond low earth orbit, medium earth orbit and geosynchronous earth orbits; provide the U.S. the freedom to operate in an expanded space domain; and have the technology and strategic reach necessary for national security while ensuring that the international commons of space remain free. Continued success in space requires that the space enterprise implement cyber-physical systems that integrate computational and physical technologies. It is essential that the future enterprise enables rapid proliferation full spectrum space operations. Global persistent awareness depends on space domain awareness, space control, and in-space logistics being able to assimilate information from a multitude of interconnected systems that can operate autonomously.

5. Developing these transformational strategic capabilities will require innovation, effective processes, and collaboration with commercial entities, allied partners, and other nontraditional sources. Critical to our ability to advance rapidly is a simpler and more responsive requirement and procurement process. This change is fundamental to developing and fielding capabilities that stay ahead of the threat. In addition, strategic foresight will be crucial to develop a depiction

of the geopolitical and technological trends of the future security environment in space. Along with the challenges of implementing such a technologically complex concept, AFSPC also recognizes the need for advances along several fronts adjacent to technology, to include policy, law, operational processes and military science. As such, AFSPC must lead throughout the R&D, prototyping, and system test and deployment process in this new, extended and collaborative context.

6. HQ AFSPC/ST will lead the incorporation of this guidance into our Command's S&T activities. My POC is Dr. Joel Mozer, HQ AFSPC/ST, Commercial 719-554-2261 or DSN 692-2261.

JOHN W. RAYMOND
General, USAF
Commander

Attachment:
AFSPC Long-Term S&T Challenges

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ATTACHMENT 1

Air Force Space Command (AFSPC) Long-Term Science and Technology (S&T) Challenges

The following instances of each challenge area are meant to be non-prescriptive, neither exclusive, nor exhaustive, but to illustrate the focus areas. These outline critical long-term S&T challenges for space over the next 10-35 years. The AFSPC Long-Term S&T Challenge areas are:

a. **New technologies for space superiority and warfighting in and from the space domain.** Technologies that ensure freedom of action in space and deny others the same, including innovative ways to achieve full-spectrum space domain awareness (SDA) and space control. New capabilities to fight through a complex, rapidly-evolving, multi-domain conflict while maintaining a state of chaos for any adversary. Technologies in this area will support or exploit: anti-access denial; automated and autonomous systems; artificial intelligence (AI); human-machine interfaces; swarms of systems; evasive mechanisms; new signal waveforms; improved cryptography, advanced computer architectures, combat cloud for communication; and cutting-edge weapons. Examples might include technologies that provide commanders with pre-decisional understanding of the space situations, adversary actions, environmental variables, attribution (natural versus man-made), and courses of action. That is, predictive and cognitive electronic warfare technologies underpinned by trusted data sources and resilient communications systems.

b. **Novel and effective ways to support the resilience of space systems.** New technologies that ensure the availability and recovery of capabilities throughout a multi-domain conflict. This area includes: resilient-by-design architectures; robust, self-healing and antifragile technologies; distributed and dynamically reconfigurable subsystems (e.g., multi-band, ultra-wideband cognitive radios; and software-defined networks and photonic devices); and techniques and technologies for defense, deception, evasion and staying in-mission throughout a conflict. Architectural resilience will be enhanced by incorporation of commercial and allied systems and technologies. Examples might include cognitive systems for secure, agile and autonomously reconfigurable communications and sensors to enhance resilience, agility and self-healing. Also included would be electromagnetic spectrum and exo-electromagnetic spectrum technologies for transmitting communications and satellite commands unimpeded and undetected.

c. **Technologies to improve access to space and to provide in-space logistics.** Novel ways to expand capabilities in space—to include activities beyond traditional low earth orbit/medium earth orbit/geosynchronous earth orbit regimes. New space lift technologies with a focus on rapid, flexible, and affordable deployment of space assets. In-space assembly, additive manufacturing, servicing, refueling, and in-situ resource harvesting and utilization. Robotic systems and standards for satellite servicing and debris mitigation. Communications and positioning navigation and timing (PNT) services based on quantum scale measurements throughout cislunar space and beyond. Support systems for human presence in an extended space domain. Space access and logistics will be developed on a collaborative basis when that collaboration enables rapid development and deployment of needed systems. Examples might

include on-orbit manufacturing by 3-D printing or other means, robotic satellite servicing or harvesting systems, movement of satellites between orbits."

d. **Enhancement and integration of existing services from and through an expanded space domain,** including communications, PNT, SDA, intelligence, surveillance and reconnaissance (ISR), missile warning, nuclear detonation detection, and space and terrestrial weather, as well as future missions of materiel storage and mobility in and through space, space search and rescue, and space commerce defense. This area includes technologies to: seamlessly integrate space services with air, land, sea, and cyber services; enhanced multi-phenomenology sensors and simultaneous observation of targets from multiple sensors for SDA ISR, and MW; novel utilization of electromagnetic spectrum and non-spectrum communications such as through exploitation of quantum-physics phenomena; edge computing; big data analytics; and AI-supported multi-domain command and control.